THE TRANSPORT NETWORK OF TOMORROW

BY TRAPEZE GROUP

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The Transport Network of Tomorrow

How public transport will become as convenient as driving a car – and the technology that will take us there.

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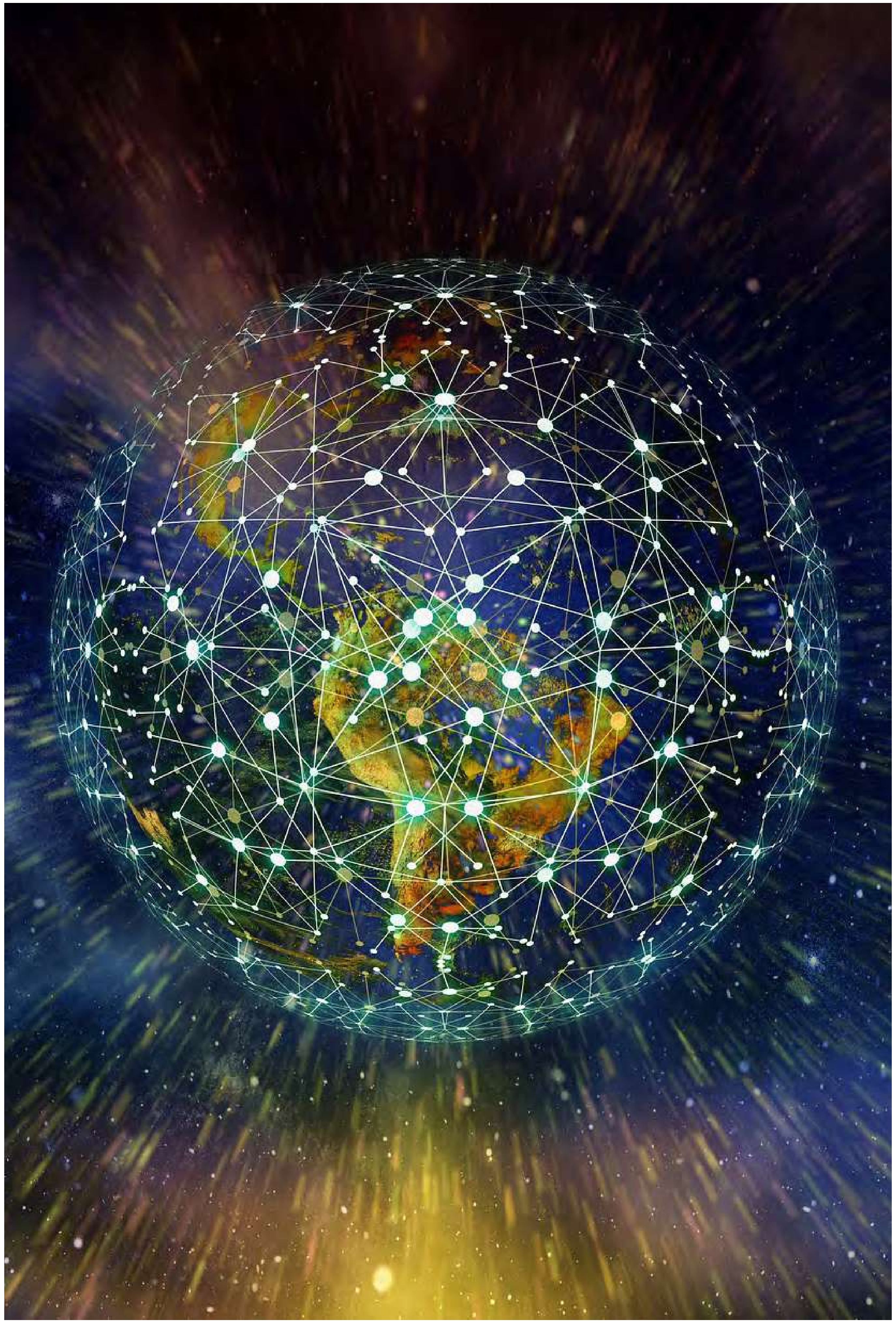


Introduction: A Vision for the Future of Transport

New forms of transport have long been a core trope of science fiction and futuristic films. From flying cars to amphibious vehicles, many fantastical machines have captured people's imaginations over the years.

Yet in reality the most transformative innovations in this sector are less related to the types of vehicle being developed, and more to do with overhauling the very structure of the industry – particularly when it comes to public transport. This point remains true in today's post-Covid-19 world – perhaps more so than ever.

In the future, public transport will be as convenient to use as turning the key in a car today.

Even before the pandemic, we were rapidly moving towards a world in which public transport is as convenient to use as is turning the ignition key in a privately-owned car today – a change which will deliver a raft of benefits for individuals, communities and the public and private sectors.

While Covid-19 has undoubtedly altered the path and perhaps accelerated the requirement to change, other factors – notably climate change and ageing populations – will require ongoing focus and a continued willingness to embrace change and find ways to adapt.

But if all this sounds overly dramatic or futuristic, rest assured that this isn't mere future gazing: The technologies that will enable this brave new world are already emerging, particularly when it comes to the bus networks in metropolitan areas. It is therefore time for authorities and operators to sit up and take note.

The drivers for change

Why are significant changes in the transport sector inevitable, especially when it comes to public transport? An array of macro factors are converging, ensuring that more of the same is no longer an option.

Climate change has rightly moved to the top of the agenda for governments and businesses in the transport industry alike. Last October, the UK government announced plans for full decarbonisation of the country's transport sector as part of its broader plans for net zero carbon emissions by 2050. Decarbonisation of public transport is a vital step in the battle against climate change; it is also a huge and complex project which will require masses of new regulation and funding.

Then there are changing living and working patterns to consider. By 2030, one in five people in the UK will be aged 65 or over, while in 50 years' time there will be an extra 8.6 million people in the UK of that age bracket – a population roughly equivalent to that of London.

Older people of course have very different public transport requirements, which will not only drive greater demand for mobility, but also demand for different routes and timings. Commuting will account for a smaller proportion of public transport journeys, while visits to public services such as health centres will increase.

Meanwhile, amidst all these changes, regulation in the transport industry is changing too. Legislation to make public transport systems more streamlined also has a major role to play, with the Bus Services Act, and its support for moves toward franchised models outside of London, a prime example.

Public transport's role in enabling commuting is also changing in line with new working practices. Even before Covid-19 many countries were moving towards a more knowledge-based economy. As flexible working becomes increasingly commonplace, accelerated by the culture shift that has arisen in the pandemic's wake, workers are more likely to be based at home some or all of the time, or travelling to work outside of normal office hours.

While it is too early to understand the true impact of Covid-19 on working practices, the reality is that this transition was already underway.

In September 2019 it was reported by the CIPD that

54% of workers have the option to work outside of typical 9-5 office hours, while....

68% of professionals here in the UK have stated that they would like the option of working outside of core hours.

Home working has therefore increased enormously over recent years, and Covid-19, together with improvements to technologies such as video conferencing and collaboration tools, seem certain to continue this trend on a powerful trajectory.

And of course, the development of new business models is also changing the way we use public transport. It is well documented that younger generations are much less likely to own traditional status symbols such as houses or cars, and are instead more used to accessing their needs as services – hence the preference for ridesharing over owning private cars.

Meeting change with developing technology

The transport sector, then, must respond to an array of evolving consumer demands and wider macro factors. To do so, it must look at a range of major technological developments – and we are now at a point where many of these developments are moving towards wider roll-out, particularly when it comes to bus services.

Clearly, buses themselves are evolving dramatically. The development of both electric and autonomous vehicles is having, and will continue to have, a substantial impact on the delivery of public bus services. Bus networks are becoming cleaner and more efficient all the time as the very vehicles populating them become cleaner and more efficient on an individual level. However, some of the most dramatic technological innovations in the public sector are happening behind the scenes and relate to the intelligent generation and analysis of data.

The Internet of Things (IoT), for example, is having a substantial impact on bus services, particularly when combined with the move to Cloud computing and the adoption of flexible mobile IP networks. By embedding smart sensors into all the buses within a fleet, for example, bus services can make smarter, more informed decisions in terms of staffing and scheduling, dynamic re-routing around disruptive incidents, and maintaining their fleets.

Smart sensors might include location trackers (linked to dynamic screens in-vehicle and at stops, to keep passengers informed of the schedule), cameras to monitor passenger numbers, and sensors monitoring engine performance, as well as connected devices keeping track of driver health, wellbeing and performance.

It all makes for much greater visibility and intelligence across the bus network, and can help power the development of services that are truly in line with passenger needs.

Many of these innovations are already in place – most of us are familiar with vehicles which automatically announce the next stop, for example – but as they begin to work together en masse, public transport providers will gain extraordinary new levels of visibility, business intelligence and responsiveness – which translates to more convenience for passengers.

AI and machine learning have a crucial role to play in this evolving landscape too, by enabling public transport providers to analyse and make tangible use of the vast and growing volume of data generated by IoT.

To illustrate, consider the requirement to ensure social distancing and restore passenger confidence by communicating live passenger loading information, enabling people to see whether an approaching bus has capacity or not. IoT technology can tell us the present level of loading; but passengers need to know the level when the bus arrives – accounting for those alighting in the meantime.

This is where the combination of IoT and machine learning can have a transformative impact. By meshing IoT information with historic data we can accurately predict future loading, offering reliable information that helps passengers and restores confidence in bus travel.

Similarly, blockchain and quantum computing are two new areas of evolving technology which can be used to solve highly complex problems such as those in relation to bus ticketing and intelligent scheduling.

Tomorrow's transport today

Collectively, these technological innovations will drive a new level of convenience and responsiveness in the public transport sector, particularly when it comes to bus services, which was impossible just a few short years ago.

Scheduling and routing tailored precisely to passenger needs; services which effortlessly flex up and down according to demand; highly efficient and de-carbonised buses, proactively monitored and maintained.

We may not yet be in the era of flying cars, but tomorrow's transport is starting to take shape today, thanks to technology developments which can meet multiple drivers for change. Later in this book we will explore those technological developments in more detail and outline how the more intelligent and sophisticated transport network of the future is taking shape today.

Chapter 1: The Internet of Things

What is really meant by the term the Internet of Things, or IoT as it is often abbreviated?

It has long been heralded as the next stage in transport development, but how IoT technology will work in practice is often more uncertain.

As a concept first, the Internet of Things describes a scenario where every sensor and device has local intelligence, and is accessible using standard Internet protocols. There are three technology developments driving IoT: the development of new mobile communications technologies such as 5G that allow devices to be permanently connected, the development of low-power, low-cost yet incredibly powerful microprocessors and the development of standard Internet protocols to allow such devices to communicate in non-proprietary ways.

The notion of IoT technology playing a central role in the transport industry is not a new idea. The desire to access accurate, real-time data from across a transport network, to process it efficiently, and then translate it into tangible actions, has been central to modern transport networks for some time. This is, of course, the process behind real-time bus information, designed to ensure waiting customers know when their bus will arrive.

However, to date, many technologies, both on-bus and at the roadside, have been proprietary in nature and have not built upon common Internet standards.

This has limited overall IoT progress, as projects often become complex and costly – particularly in scenarios where information originates from sensors in different domains, such as traffic light priority and environmental sensing at roadside.

However, things are changing, particularly in the bus sector, where there is increasing drive towards open standards. We are moving into an era of IoT-powered public transport: one which will deliver enormous benefits in terms of efficiency, environmental footprint and passenger experience.

The development of new mobile communications technologies such as 5G will enable devices to be permanently connected.

Better bus scheduling

Let's focus on the bus networks in metropolitan areas. In recent years we have seen increasing migration to towns and cities, especially to the centres of such urban areas, as opposed to the suburbs.

While Covid-19 has, at least temporarily, cast a degree of uncertainty over this trend, there is little doubt that demand for highly efficient bus networks, responsive to passengers' working and leisure patterns, will increase. Likewise, the requirement for environmentally efficient bus services, minimising carbon footprint and air pollution, has never been greater.

IoT technology has been present across most established bus networks for a number of years. The majority of passengers have used buses that provide current and next stop information, or have waited at stops with digital signs offering live arrival information.

These real-time systems were originally designed using proprietary protocols. For example, an on-bus GPS tracker would use a dedicated radio channel to communicate – via a supplier-proprietary protocol – with the bus stop in order to update the bus stop display on arrival and departure.

This technology was replaced around seven years ago with a system that saw the buses transmit information to a back-office system, which then relayed messages to the next bus stop. The net result was the same – dynamic alerts at each stop regarding bus arrival times – but it removed the need for buses to be fitted with dedicated and expensive radio hardware specific to the particular site. It also removed the requirement to fit every sign with a specialist radio receiver, making it possible to exploit far cheaper mobile network technology.

Tomorrow's IoT-powered bus networks will benefit from these micro sensors being both far cheaper (perhaps £10 per bus, rather than £1,000!), and also compatible with open standards – so all bus stops, buses and even traffic lights will communicate in the same language. Such standards will no longer specify bits and bytes; instead, they will focus purely on content by building on industry-standard protocols such as IP, HTTP, JSON, XML and RESTful.

Even more excitingly, a new family of Internet standards have emerged over the last few years that enable a device to query the capabilities of another, and then adapt how it interacts based on the remote device's capabilities. GraphQL is an example of such a technology.

These cheaper yet more sophisticated micro sensors will be able to capture information such as ridership numbers and wait times or the condition of on-board equipment making it far easier for operators to plan and manage routes – something that is particularly challenging today.

Dynamic schedule management capabilities will improve, with operators better able to re-route buses around incidents and plan routes and timetables in-line with fluctuating demand. And when buses are cancelled, the affected individual journeys will be identified so that passengers can be proactively presented with alternative options.

In other words, a combination of cheaper hardware and interoperable, open source software will result in smarter, more efficient and more passenger-centric bus scheduling.

Sophisticated micro sensors will be able to capture information such as ridership numbers and wait times,

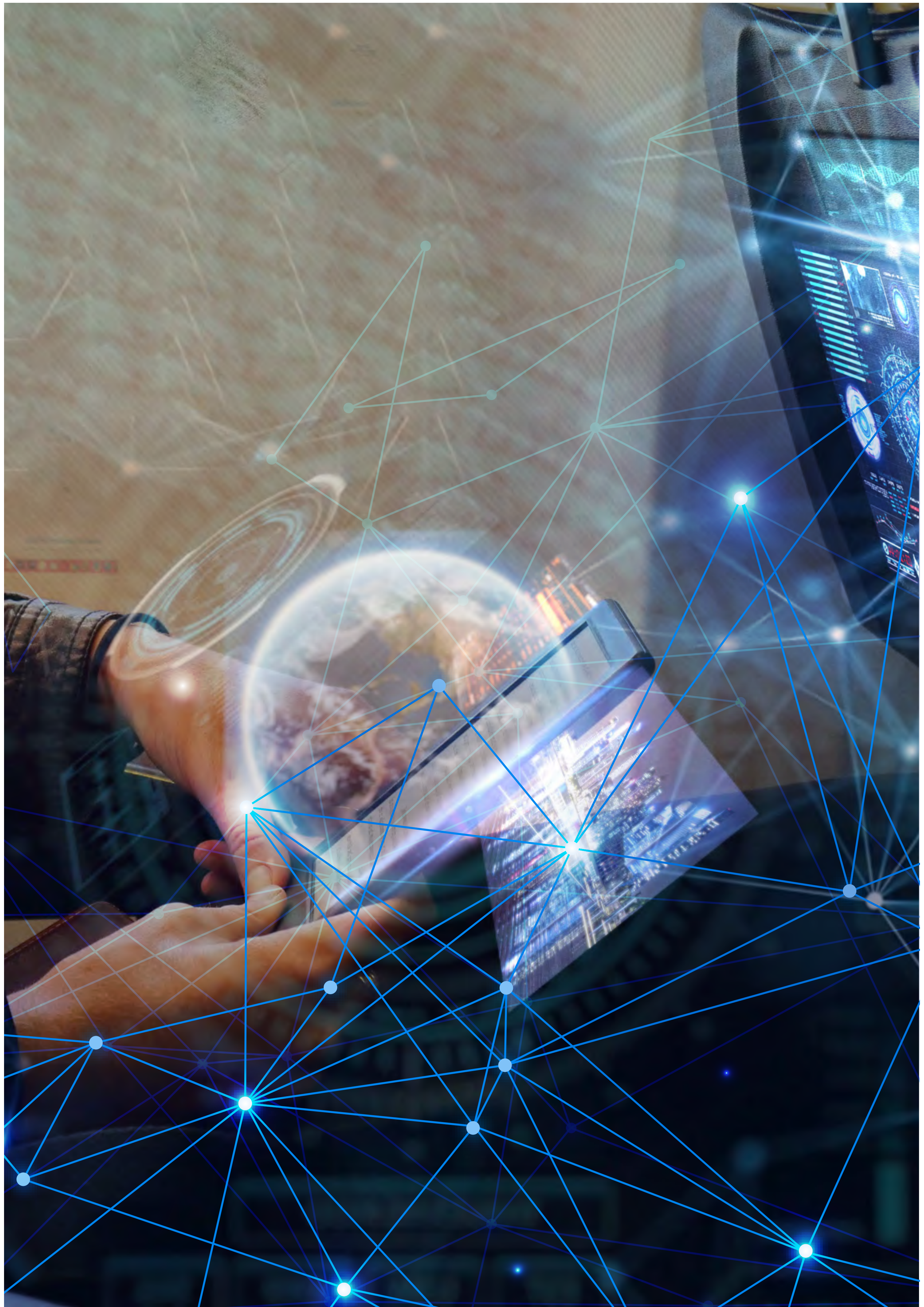
Better passenger experience

Passengers will also benefit from a wider use of IoT sensors. Consider, for example, in-vehicle speakers which announce the bus's location, next stop and provide other key passenger information. Getting the volume right is difficult: it is easy for one speaker to be too loud, while another is too quiet due to ambient noise, the position of the speaker relative to the engine, or seats absorbing sounds.

In the future, each speaker may be an intelligent node with an in-built microphone that auto-adjusts volumes to ensure a consistent passenger experience. This could even change dynamically, for example when a group of boisterous school children boards the vehicle.

Looking further ahead, there is a role for IoT sensors in tracking physical factors on individual buses. Companies are already working on using vehicles' in-built sensors to track engine performance, enabling buses to be more proactively and predictively maintained, reducing breakdowns and improving passenger experience that way.

In the future, this could develop into monitoring faults on auxiliary systems – for example, in the instance of a fault with a wheelchair ramp, passengers could be proactively informed, enabling them to choose an alternative bus.

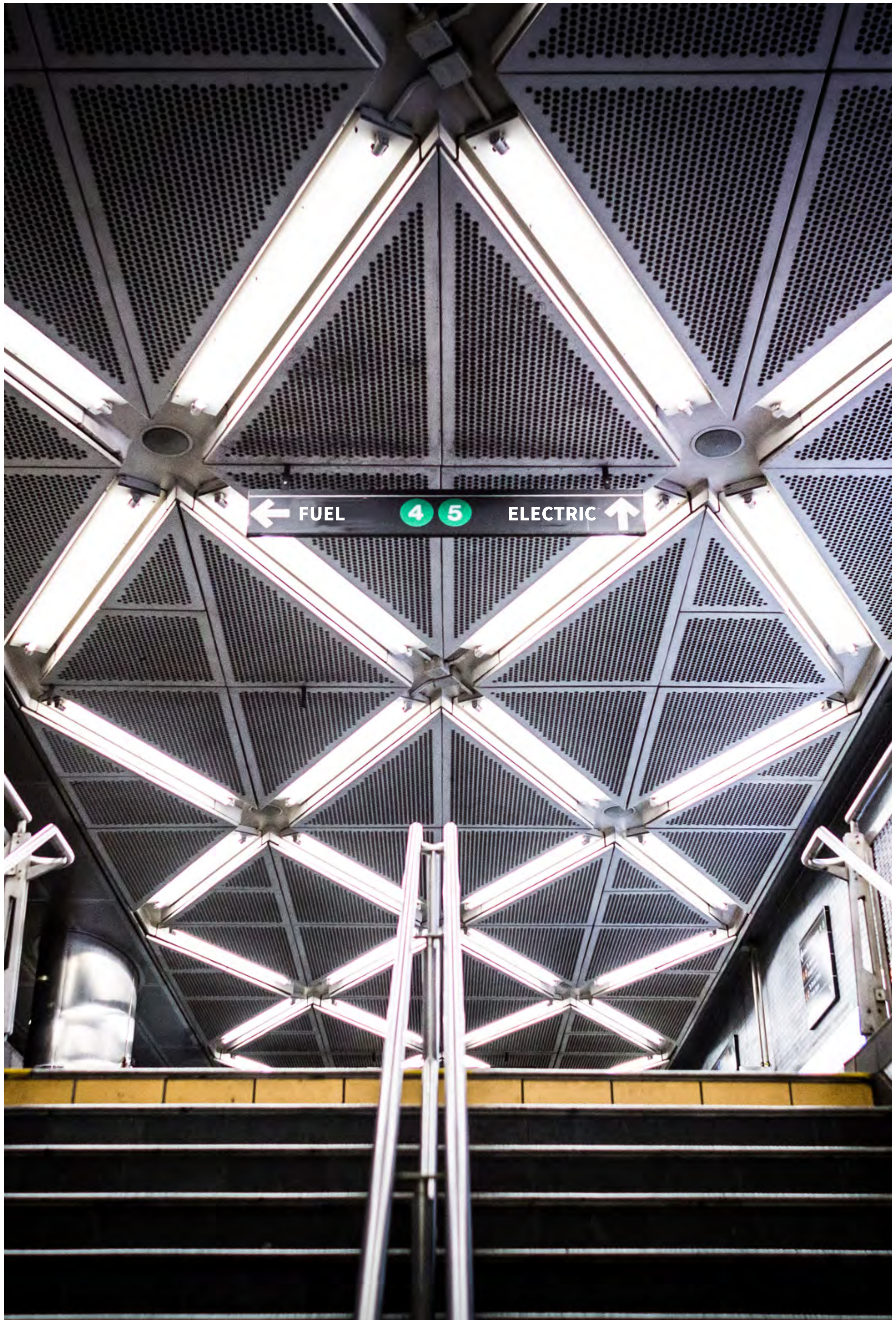


Tomorrow's transport, powered by the IoT

With Smarter Cities becoming an increasingly hot topic, the real power of IoT will emerge through the combining of transport data with other sources of data. IoT offers extraordinary opportunities for great intelligence, automation and responsiveness. It has the potential to power intelligent bus scheduling which responds dynamically to passenger needs and environmental conditions such as traffic and pollution levels. It also has the potential to better inform passengers during journeys, and to keep vehicles in better condition for longer.

However, for these benefits to be harnessed cost-effectively and comprehensively, we must move towards common IoT standards. Proprietary hardware may have enabled bus operators to dip their toes in the IoT era, but it is ultimately too costly and restrictive to be a realistic approach for transport operators nationwide. The ITxPT initiative is a key industry forum making this happen.

The drive to open standards that has already begun will enable vehicles and points throughout transport routes – such as bus stops and traffic lights – to share information with one another seamlessly and dynamically, no matter where they are located, or which transport operator is in charge.



Chapter 2: Electrification

There are plenty of factors which require careful planning when it comes to management of bus transport, including route planning; driver scheduling and shifts; and vehicle maintenance. Fuel, however, is not typically one of them.

Today, most vehicles are able to carry a full day's worth of fuel, simply refuelling at depots overnight. The risk of running dry mid-journey; and the matter of when, where and how to schedule refuelling stops throughout the day, are not factors with which operators have needed concern themselves.

However, the era of electric vehicles will, of course, radically change this situation.

On the one hand, electrification requires bus schedulers to consider a question they have never before had to work with: how do you manage scheduling and route planning when buses require recharging through the day? On the other, electrification also has the potential to introduce a whole new scale of efficiencies, both in terms of day-to-day bus operations, and longer-term planning and scheduling.

In short, electric vehicles could utterly reshape the transport networks of the future and how they are managed.

In February, the UK government announced a £50 million plan to create the country's first 'all-electric bus town', ahead of working to ensure all buses are fully electric by 2025. Electric bus fleets are of course not a pipe dream; they are rapidly becoming a reality.

So how can operators balance the downsides and upsides? And what technologies need to be combined with electric vehicles in order to truly harness the benefits of this new era?

The downside

The major downside of electrification in the bus industry is that a single battery charge will, at least for the next few years, not be sufficient to drive a bus for a whole day.

In other words, intermediate charging will be necessary throughout the day, and this will need to be taken into account when scheduling the bus. A new factor is therefore layered into the process of bus scheduling, and this means scheduling algorithms need to become more sophisticated.

In the electric era, bus scheduling algorithms will need to look at the increased need to calculate a bus's optimal route and charging times, to ensure the vehicle asset can be utilised as fully as possible. Real-time prediction of what the bus is going to do becomes absolutely essential in this scenario, because buses cannot be allowed to run out of electricity before reaching a charging point.

This requires Internet of Things (IoT)-enabled sensors which are able to measure not only the location of the vehicle, but also the battery's remaining charge; as well as factors which will affect how quickly it drains – including the likely speed of travel, number of passengers and any other loads, energy usage from in-vehicle USB charging, and weather conditions.

And of course, there is also a requirement for an algorithm which can analyse all of this information on an ongoing basis – along with the time it will take the bus to recharge at the next stop – and feed all these calculations into broader bus scheduling.

This means that machine learning and predictive analytics will become essential tools in order to avoid potential headaches for operators.

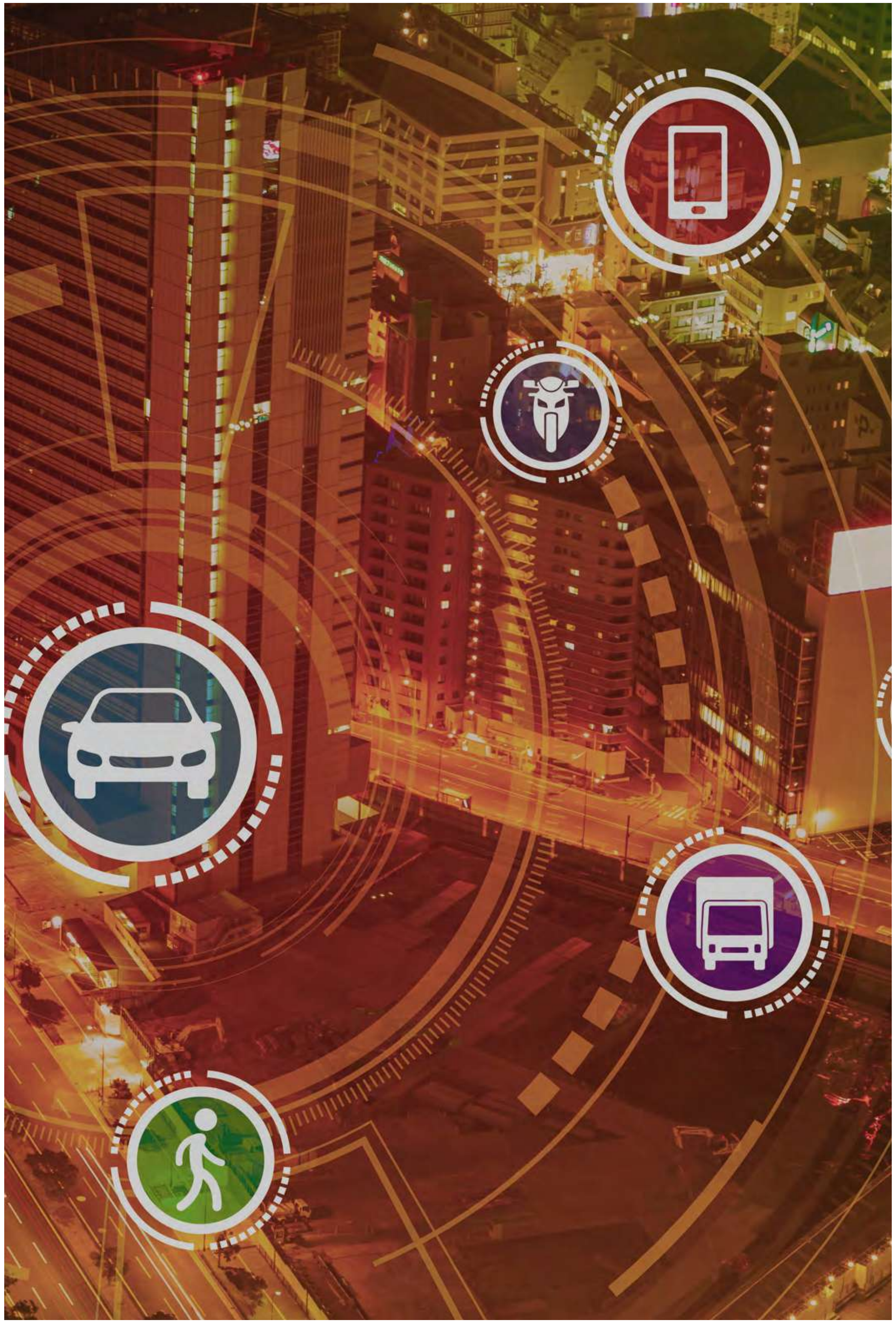
The upside

Now for the advantages – and there are plenty.

First, many people underestimate the reliability improvements associated with electric buses. They break down far less frequently than typical diesel buses, meaning that the time and cost of maintenance is reduced, as well as negative impact of mid-operation breakdowns, which understandably frustrate passengers, introduce PR headaches, and undermine all-important faith in public transport. Diesel drive chains are much more complex and liable to mechanical issues compared to electric vehicles.

Second, the passenger experience in electric buses is far superior to that in diesel-powered buses. The ride is less noisy, not only because of the quieter engine, but also because there are fewer rattles caused by components vibrating due to the diesel engine. Acceleration is smoother, and of course, air quality is improved.

Third, because, as mentioned, there are far more vibrations and temperature fluctuations associated with diesel engines, this poses challenges for in-vehicle electronics. For example, starting the diesel engine leads to significant drops and spikes on the electric supply lines in the bus. This not only leads to reliability issues for other systems, but can also make it more challenging to install sophisticated IoT sensors.



And this brings us back to the challenge of optimising the charge on electric buses. If operators can use IoT sensors and machine learning to master the art of finding optimised schedules for electric vehicles, they will be able to run services which are far more efficient overall.

Meeting the challenges head-on

There is no doubt that electric vehicles pose some new challenges for bus operators in terms of scheduling. A whole new factor is being introduced into route planning, timing the gaps between buses and the time spent at stops – no longer will driver shift patterns be the primary factor in scheduling vehicles.

However, their effective use is a key element in the transport vision of the future. By generating better data from across the bus network through more capable and cheaper IoT devices, and then using machine learning algorithms to turn this data into tangible insights, public transport executives can dramatically improve the overall bus experience.

In the next chapter we will look at how advances in machine learning and computing capabilities can handle and process this information in a way that will further improve the passenger experience on the network.

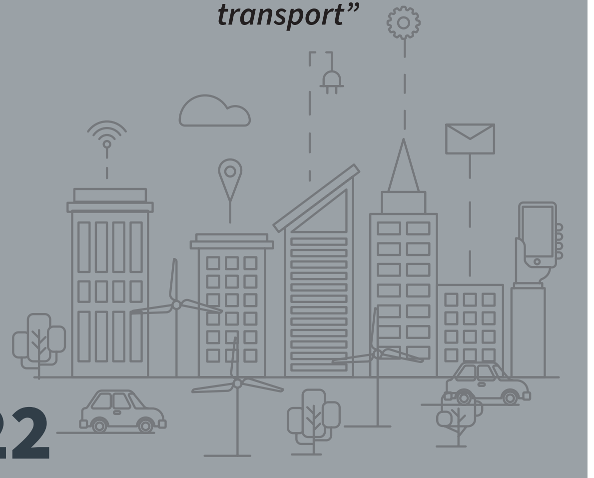
Chapter 3: Shared and Smart Ticketing

Local authorities need to get more people using public transport. The challenges of climate change and environmental pollution, growing urbanisation and ageing populations mean that running convenient and efficient public transport networks is critical.

This, of course, is even more challenging – and even more important – in a post-Covid world.

But passengers cannot be forced into making the choice to use public transport; we need to make it the best option so that they want to. Therefore, if individuals and families are to forgo using their own vehicles, public transport must be made as reliable, efficient and, ultimately, just as convenient as driving a car.

"... passengers cannot be forced into making the choice to use public transport"



Today, in the fragmented UK transport market, ticketing can sometimes feel a significant barrier to an easy journey. A journey involving two buses, metro and a long-distance train may require four separate tickets – each subject to different rules and tariffs.

In other words, smart and shared ticketing initiatives are vital from a convenience perspective. Public transport executives and other combined transport authorities have long recognised the value in enabling a range of journeys to be paid for via a single smart card. The trouble, of course, is that putting such schemes into practice can be rather complex.

Today's shared ticketing schemes are largely powered by a standard Department for Transport (DfT) backed standard called ITSO, which requires substantial investment in back-office technology, as well as a sharing agreements between all scheme participants.

This makes adoption of such schemes costly and often problematic. Is there an alternative?

Understanding ITSO and HOPS

First, let's get to grips with ITSO, which has been enabling smart ticketing in the UK since 2002. ITSO is both a specification for enabling smart ticketing, and the body which supports members in setting up and running ITSO-compliant smart ticketing programmes.

In other words, it helps transport operators to ensure the security of the smart cards used by passengers, to manage transaction data through a smart ticketing programme, and to share data between interoperable schemes – such as those run by different operators within the same area.

A crucial part of ITSO smart ticketing programmes is the HOPS (Host or Operator Processing System), which is the smart ticketing transaction processing engine built to the DfT's ITSO specification. This backend system is responsible for collating all transactions and determining settlements between the different scheme participants. Because of the challenges of getting the HOPS certified, there are only a very small number of suppliers for such systems.

In practice this means that UK transport operators wishing to implement a smart ticketing scheme have little choice but to participate in the same ITSO programme – and invest in the same costly back-office HOPS system.

Things become even more complicated when combined transport authorities implement shared ticketing schemes across multiple operators – for example, creating a single smart

card which passengers can use across all bus companies within a particular county or city. In these instances, every operator within the scheme must separately implement the same technology, creating a high barrier to entry to new operators joining a shared scheme.

In turn, this makes it harder for such schemes to optimise convenience for passengers, because it is more likely that certain operators will not participate. So what was intended as a single smart card for use across an entire area ends up as something rather more piecemeal.

If a multi-operator journey cannot be made using a single smart card, then the vision of assured passenger convenience is lost.

The blockchain alternative?

In response to these issues, the Trapeze team have been focused on exploring potential ways to offer passengers the benefit of multi-operator ticketing while avoiding the need for a complex back-office through which all transactions have to be channelled.

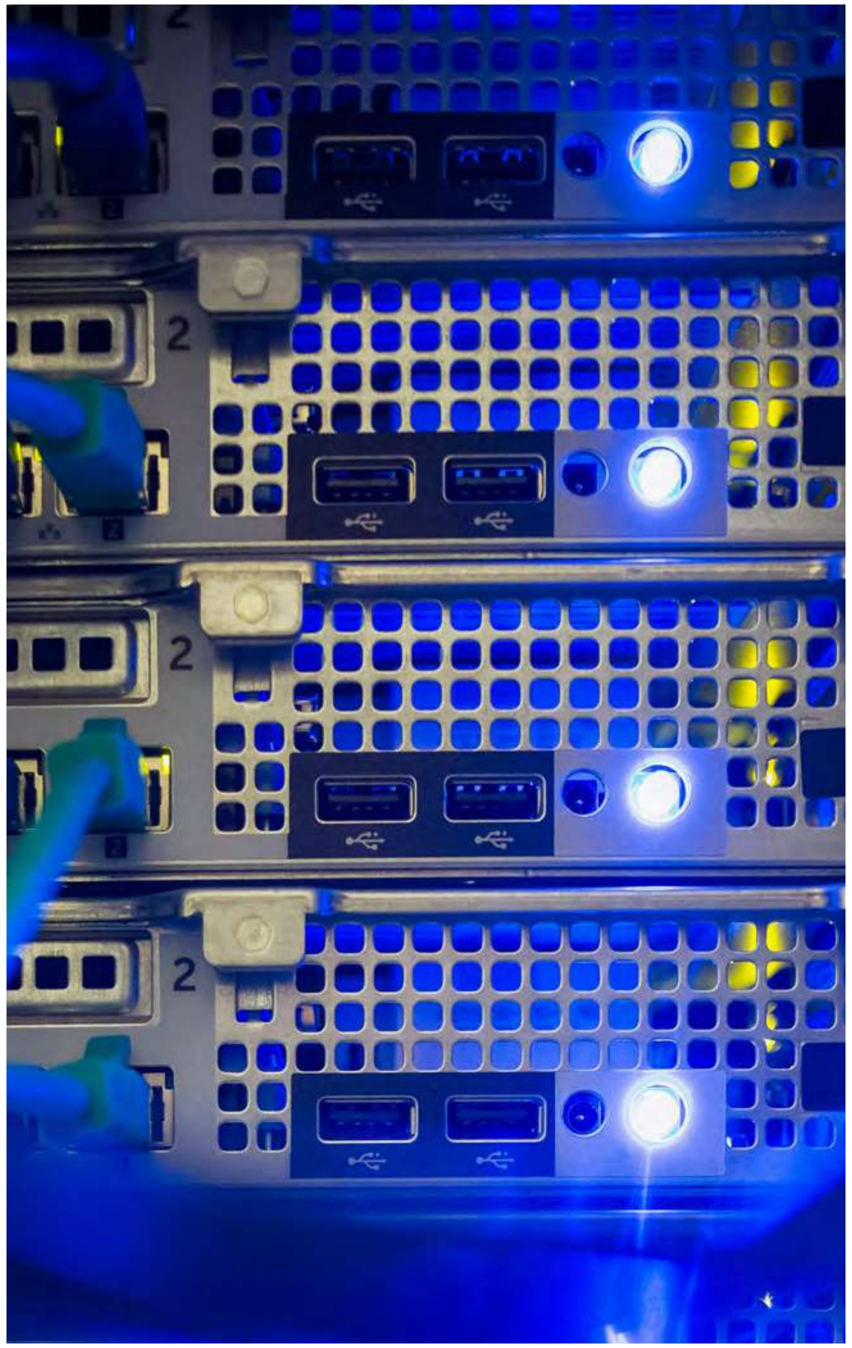
This approach recognises that being limited to a single (costly and complex) choice for any element of enterprise technology is never the best option – either for the organisations deploying that technology, or their customers.

Having reviewed the options, we believe the open-sourced blockchain algorithm could form the basis of such an approach.

Blockchain, which is perhaps best-known as the algorithmic technology underpinning cryptocurrencies such as Bitcoin, could offer a true open source alternative when it comes to shared and smart ticketing.

One view of the truth

In simplest terms, a blockchain is a single distributed ledger. Individual users cannot add a new line or transaction to the ledger without other users receiving a copy of that line – which means that it is impossible to falsify or hide transactions. Each participant in the blockchain sees the same single version of the truth at all times, and therefore all can trust it completely.



Importantly, there is no central authority in blockchain, and the algorithm ensures that everyone can trust updates to the distributed ledger without explicitly knowing the other participants.

Additionally, because there is no central registry of participants, new participants can join the ledger without the need for complex data sharing agreements.

This technology has proven phenomenally useful in creating digital currencies which can be used worldwide – and exactly the same principles could underpin the shared ticketing systems of the future. In such a system, each passenger – and every bus operator – would have access to the same blockchain ledger. It would track each individual transport user's journey and associated spend, adding a new line to the same ledger for each journey, no matter which operator had provided the transport.

In recent years, there have been further evolutions of the blockchain algorithm. In particular, Ethereum adds the ability for trusted programs to perform the update to the ledger. Such an approach could be expanded to support a distributed ticketing system allocating revenues based on previously agreed principles for a multi-operator trip. From the passenger perspective, convenience would be absolute. They would simply load a certain value onto their blockchain account, through whichever public transport executive was overseeing the scheme. That executive would be in charge of reconciling the ledger, ensuring that the appropriate sums were distributed to each operator.

Yet from the operator perspective, convenience would also be maximised. The need to develop and maintain shared technology platforms would be reduced for a start.

However, the cause of multi-operator journeys would be advanced by far more than simple cost savings.

A shared ticketing journey could be accurately calculated using the blockchain ledger without any direct contact from operators. This would mean shared tickets could be provided for bespoke user journeys, increasing revenue as users opt for this more convenient approach to transport.

Chapter 4: Advanced Computing

It is easy to envisage the physical elements of the transport networks of tomorrow. Fully electric vehicles moving seamlessly between destinations. Beautifully efficient services, which arrive precisely where they are needed at precisely the right time, with passengers kept up to date via high definition, real-time information screens

It is more difficult to appreciate the data management required to underpin this vision – yet this is precisely what will define how well these transport networks operate.

As the implementation of Internet of Things (IoT) sensors on vehicles increases, the volume of data generated will also increase. Information relating to bus location, speed and passenger numbers – as well as, potentially, environmental conditions such as temperature and humidity, engine condition and even driver health and wellness – will be available to both operators and transport users.

However, the benefits derived from this data will depend on access to advanced computing which can analyse such information in vast quantities, combine it with other data sources, and translate it into tangible, actionable insights.

Two trends – one already present but growing; the other only just emerging – will help to deliver this new future. Let's explore them.

Machine learning

Machine learning – that is, computers using algorithms and statistical models to perform tasks without explicit instructions – is by no means a new development in enterprise IT. But the breadth and power of its applications have grown enormously in recent years – and the transport industry is no exception.

Broadly speaking, there are three useful applications of machine learning in developing tomorrow's transport networks, particularly in the bus industry.

First, machine learning enhances upfront planning, such as the development of schedules and timetables. Second, it enhances the actual delivery of services, for example, enabling more dynamic and accurate responsiveness when allocating drivers and vehicles. And third, machine learning enhances problem solving – responding when something has gone wrong on the network.

One area relevant to all three applications is demand prediction: that is, understanding when and where buses will be needed, assigning them accordingly, and also understanding how changes to the network will affect demand – whether they will improve or damage it.

Demand prediction can be undertaken as part of proactive planning, ongoing service delivery, and incident resolution – and machine learning will enable bus operators to make better use of data throughout.

Traditionally, demand prediction in the bus sector has relied heavily on the 'gut feel' of experienced commercial managers. They have powerful insights developed through years of experience, but greater access to data and machine learning algorithms enables them to become even more effective at predicting demand.

As an example, today's planners can only understand how long a bus is likely to take to travel between two stops, and how long it will dwell at a particular stop, by looking at historical averages. This is relatively 'dumb' data: it doesn't take account of what is actually happening in the present moment, such as weather conditions, bank holidays, roadworks and so on.

Equally, when local public transport networks are disrupted, recovery decisions are taken by service controllers based solely on experience and instinct.

Through a combination of better data collection from across the network, and big data analytics which enable algorithms to learn to forecast how the current situation may evolve, we will radically improve the accuracy of such predictions – I believe up to 95% or more, in comparison with the high 80s today.

In turn, this will enable operators to use data and modelling to determine the best possible response to an interruption in services. Experienced managers will be able to augment machine learning insights with their own expertise, or with knowledge that the algorithm does not have – for example, a one-off event taking place that day.

Once processed, this information can also be more readily shared with passengers, ensuring real-time passenger information systems also become more informative.

Emerging quantum computing

There remain, however, problems that are difficult to tackle with conventional computers.

In the bus industry, one of our greatest challenges relates to optimising pickups and drop-off routes – sometimes referred to as the 'travelling salesman problem'. Given a list of destinations and the distance between each, which is the shortest possible route which visits each of them and then returns to a set location?

Traditional binary computers cannot tackle these problems because they work by checking each individual solution – and in such scenarios there are simply too many to assess.

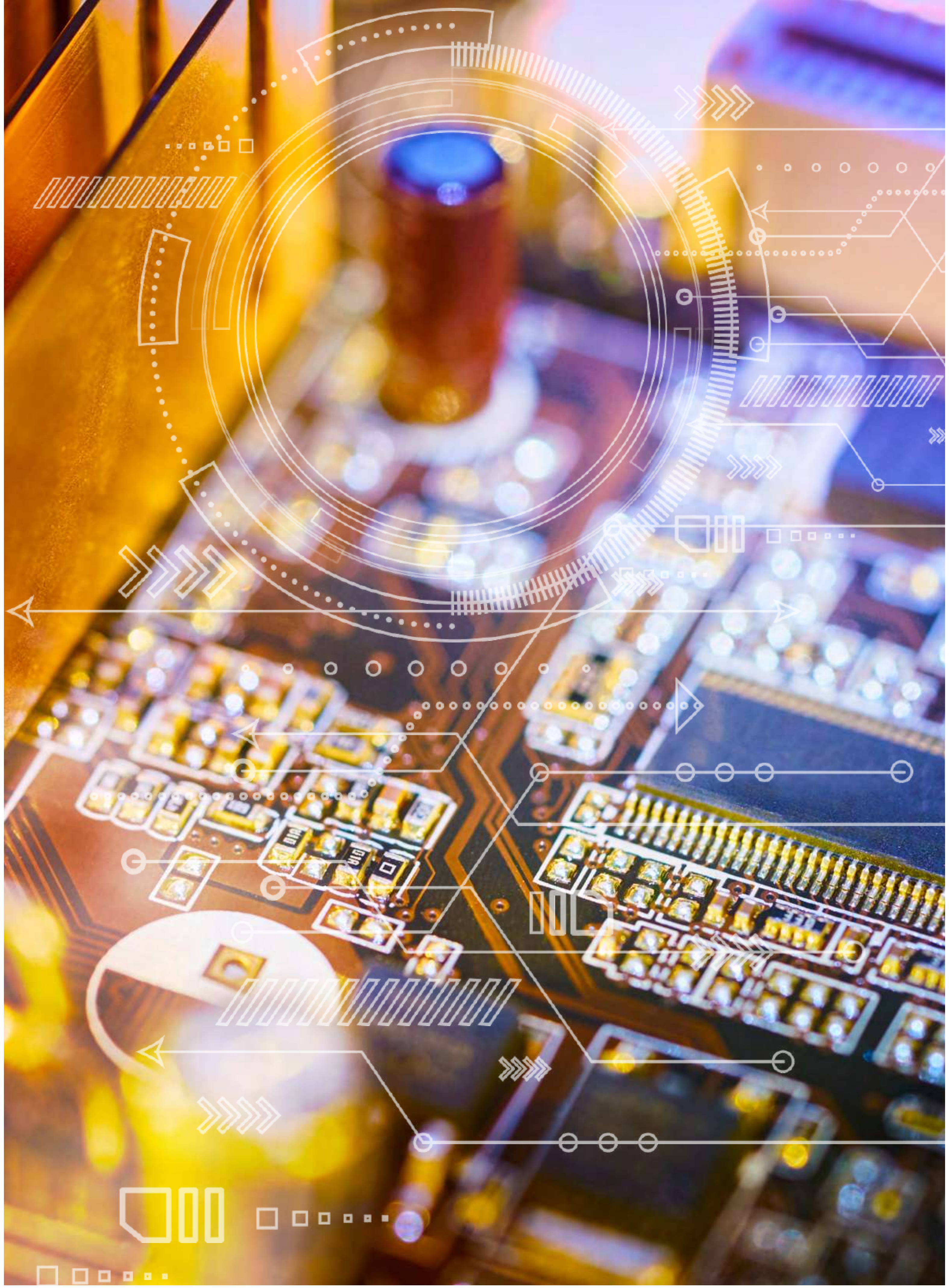
This is particularly crucial as demand-responsive services become increasingly important, either as part of responding to the needs of an ageing and urbanised population, or to reduce environmental impact.

The sheer scale of the first-mile, last-mile pickup and drop-offs for large numbers of people is such it is not possible to provide real-time optimised scheduling using traditional binary computing.

Enter quantum computing.

In the binary world, everything is either a 1 or a 0. But in the quantum world, information can exist more readily outside of a defined state – and can actually be in multiple states at the same time.

Without getting too abstract for our purposes here, this presents the possibility for solving vastly complex problems in a very short period of time



– including analysing point-to-point journeys across an entire city.

Crucially, this does not mean that bus operators will need to build and own their own quantum computers. Computing giants like Microsoft are already developing quantum computing toolkits whereby companies or individuals are able to design their own quantum computing programmes in Visual Studio, upload their data – and then Microsoft will run that programme for them and return the results via Cloud-based services.

I expect that in just a few years' time we will see transport operators uploading vast quantities of pickup and drop-off data into such a programme – and almost immediately receiving back the optimised route, using the same cloud hosting model that has defined the last decade of computing.

The greater prevalence of IoT sensors and data throughout today's transport networks has the potential for driving huge innovation and efficiencies – but only if the computing power is available to translate this data into tangible, actionable insights.

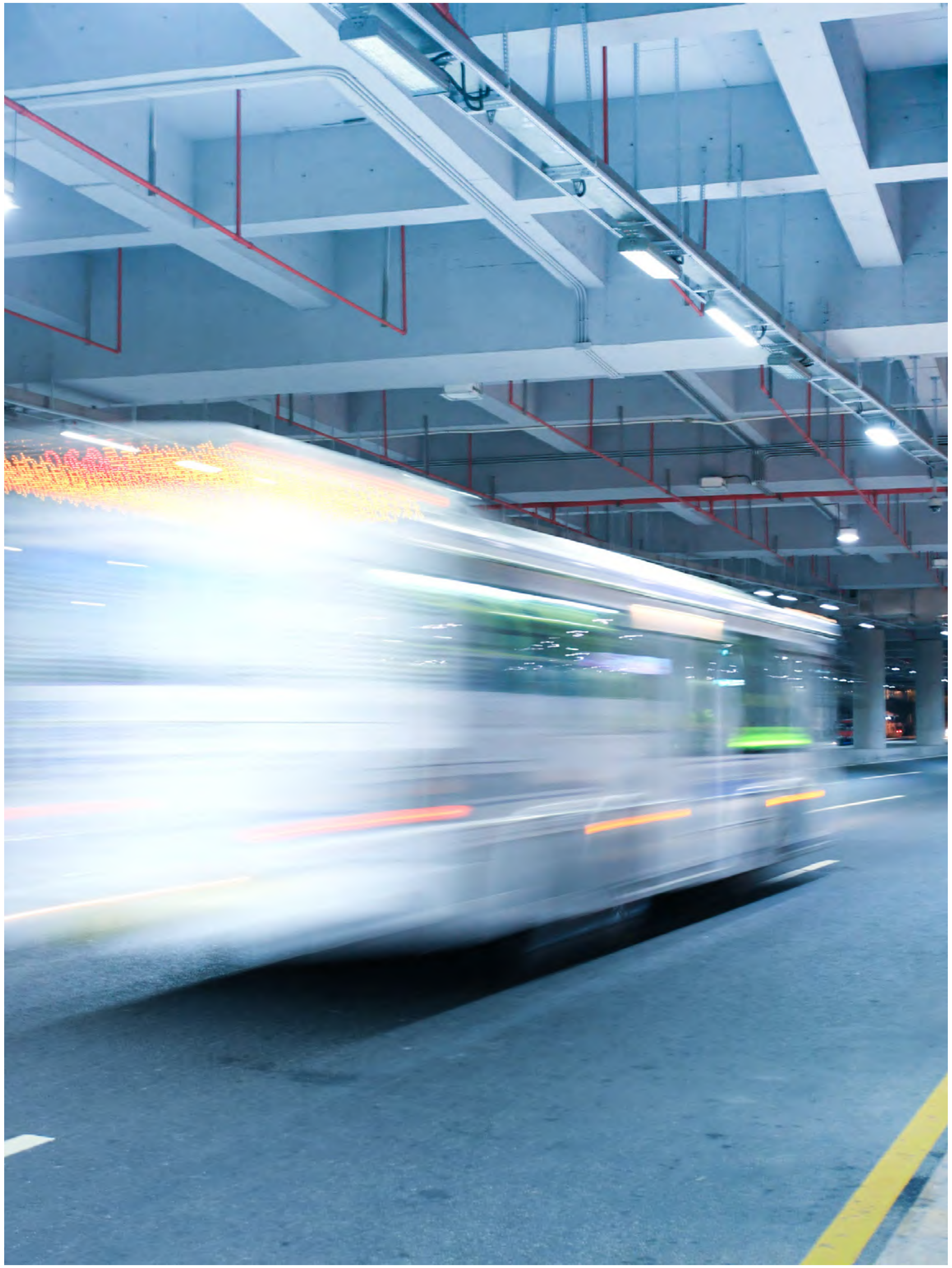
Machine learning is already making this more manageable. But in the future, quantum computing will take it to place that would have been unimaginable just a few short years ago.

Chapter 5: Dynamic Scheduling

One of the many profoundly transformative aspects of the Covid-19 pandemic is the way that it has accelerated change in society. Existing trends such as working from home and digitalisation of everyday lives have been turbo-charged, effectively condensing more than a decade's worth of anticipated change into a few short months.

With standard behaviour patterns thrown in the air and confidence in public transport severely undermined, we face a difficult and uncertain future. Suffering reduced bus revenues, bus service providers must find ways to continue delivering safe and reliable mobility.

The challenge here is that in 'normal' circumstances a sensible response to falling demand might be to reduce services to match ridership. But of course, that model won't work well today because a) passenger numbers are restricted for social distancing, and b) a reduction in services will reduce overall mobility options, thereby eroding fragile faith in bus travel.



And if all this were not worrying enough, consider also the wider implications of a world where more people shift away from public transport in favour of private cars, Uber and taxis.

Today many cities have almost as many cars on the streets as before Covid-19. We could well be standing on the precipice of a congestion and air quality disaster – one that will introduce more traffic, more pollution, and a climate crisis moving faster than ever. We must take a step back.

Navigating the New Normal

Bus ridership has taken a huge hit everywhere. At the time of writing, in London passenger numbers have recovered somewhat, but only to around 40% of pre-Covid levels. DfT data suggests similar levels across the UK outside of the capital – and this is of course consistent with stories emerging from all over the world.

If we want public transport to remain relevant and reliable, with strong bus ridership (within current social distance-defined levels), we must offer passengers the same quality and reliability of experience as before Covid-19 – but with fewer vehicles.

This, of course, is a phenomenal challenge. However, it is perfectly possible, but it will require us to completely reimagine our networks – and the way to do that is with data.

Managing Disruption

So, we know that we need to redefine our networks to meet future demand. This kind of forward prediction necessarily requires adequate management of disruption, and here there are three time frames that must be considered:

Near short term: In the uncertain post-Covid (and beyond) world, networks must be adaptable for a few hours at a time. This would typically be in response to police incidents, emergency road closures, accidents or terror threats.

Short term: We need to consider the ways in which we can adapt the network for slightly longer periods, of perhaps a few days at a time. This might be to manage severe weather events, which are an increasingly likely consequence of climate change.

Long term: Networks must be adaptable for longer periods, measured in weeks or months. This kind of disruption may include the kinds of changing ridership patterns we have experienced with Covid-19.

Wanted: Unavailable Data

The one major problem with this requirement is that for this kind of forecasting the data we need isn't historic; it's future. The events we need to model haven't happened yet.

Fortunately, this actually isn't the insurmountable problem some might expect: this is where machine learning and dynamic forecasting can help, by creating a dynamic 'forward simulator' that can predict what will happen to a network in terms of the three time frames outlined.

This simulator would require additional input from external sources that may directly affect the network, for example an interface with the police to implement any road closures or similar issues.

We also need to be able to forecast travel times, enabling us to understand where and when people will be traveling, and making it possible to flex resources to ensure the network meets actual demand.

New Ways of Thinking

While the public transport sector has done a good job of utilising available data – think how journey planners have transformed mobility in urban areas for example – the data we will need to build dynamic networks and schedules simply doesn't exist at the moment.

Recognising that genuine expertise and new ways of thinking are required, my R&D team is currently working with a range of external partners on three major research projects that will make machine learning and dynamic forecasting a reality.

Trip Times Predictions: We are working with a top British university on a trip times predictions algorithm. Already we are seeing 98% accuracy for 'here and now' predictions – an encouraging outcome, though further research is needed into how we use this in the long term.

Interventions: This theoretical simulator shows possible events in the network, and is currently being used to train machine learning algorithms to recommend the best strategy in managing disruption.

Demand Prediction: We are in the process of building another theoretical simulator which will enable us to build bus networks and see what algorithm works best.

Looking Ahead

There are vast challenges ahead of us. However, in machine learning and dynamic forecasting we have the tools to build a dynamic new future for bus networks.

By harnessing these tools we will not only ensure the flexibility that is essential as we emerge from Covid-19; we will also restore faith in buses and public transport in general, creating a cleaner, greener and healthier future.

Conclusion: Building A New Future for Transport

Of the countless transformative aspects of the Covid-19 pandemic, in the long term one of the most profound may relate to environmental concerns. Confidence in public transport has been badly damaged, but it must be restored if we are to avoid a congestion and air quality disaster.

The key to this challenge is to ensure that public transport tomorrow is as convenient and reliable as turning the ignition key in a privately-owned car today.

But at the same time we must recognise that existing public transport delivery models may require reform. We need to think radically about how to offer passengers improved quality and reliability of experience – often with fewer vehicles than in the past.

The good news is that all of this is entirely possible, and the technologies that can underpin a brave new public transport world are already emerging.

IoT, Electrification, Shared Smart Ticketing and Advanced Computing will be central to our future, and by harnessing them we can build more dynamic, demand-based services that better meet passenger needs, while managing strained budgets through Covid-19 recovery.

In this way we can not only emerge from this difficult situation, but bounce back stronger and more resilient than before. In the years to come our ability to react to change is likely to be put to the test and we must adapt – because if 2020 has taught us anything it's to prepare for disruption.

While we may not yet be in the era of flying cars, perhaps a transport network of tomorrow – one that is greener, cleaner and benefits individuals, communities and the public and private sectors – is something even better to aim for.

It is a uniquely fascinating time to be involved in transport and technology. I hope you have found this book valuable and I look forward sharing this most exciting of journeys with you in the years to come.

About Trapeze Group

Public transport is more than buses, trains and taxis; it's how we as a society connect families and friends; children with their schools; and workers with the jobs that drive our economies.

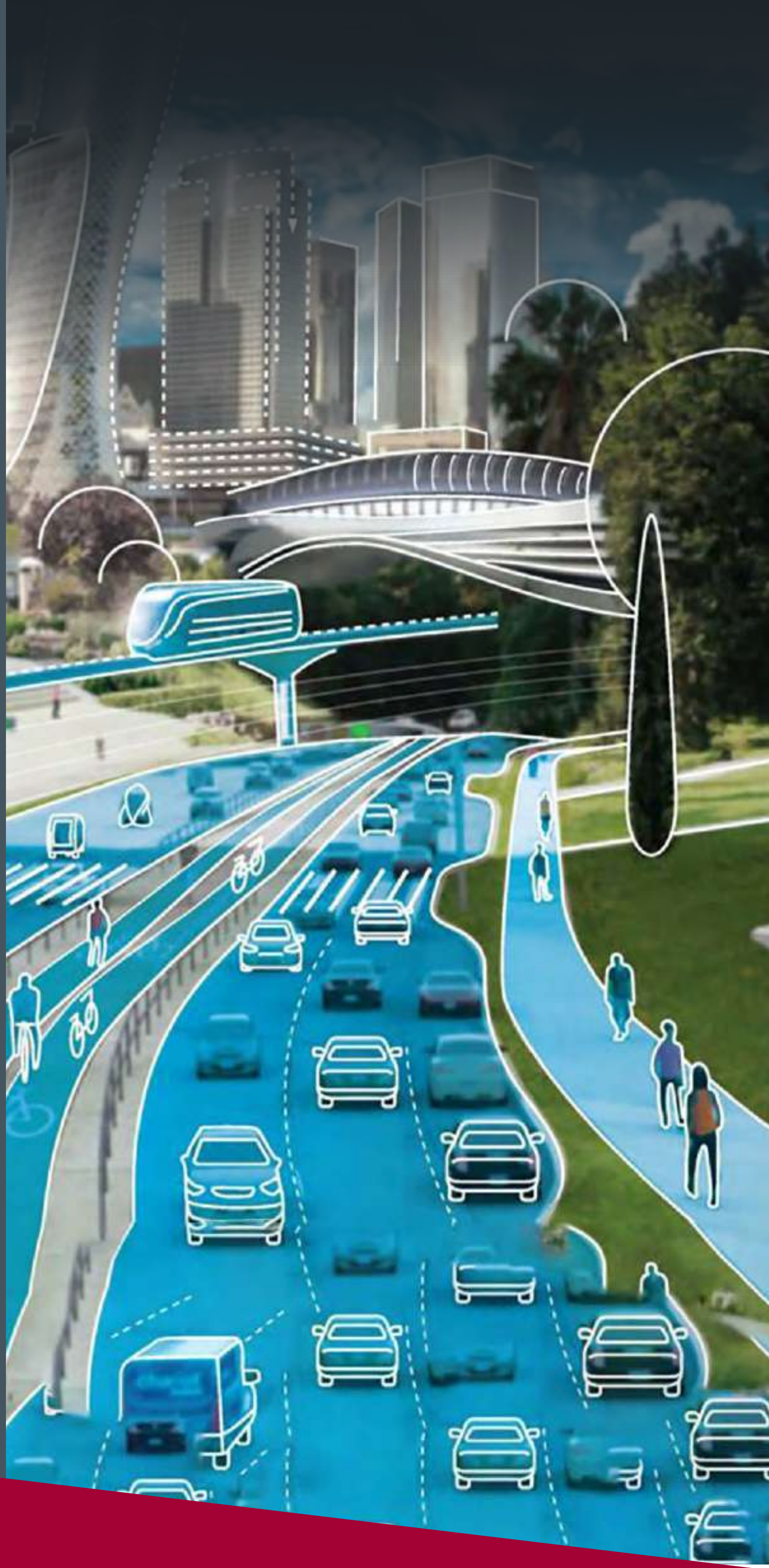
Every day, UK transport providers strive to deliver mobility for those in their communities – in many instances for those for whom that need is greatest of all. For so many of our customers, public transport is far more than a job – and we are continually inspired by their dedication.

As stakeholders in the public transport sector, we aim to match that dedication; recognising that we too play a vital role in this transport ecosystem. As Local Authority budgets continue to shrink – and commercial operators face similar constraints – our customers rely on us to deliver the tools they need to do their jobs with ever more efficiency.

Together we are working to increase the effectiveness of public transport; promoting it as not only the transport system of tomorrow, but of today.

We all aspire to sustainable forms of transport, but if we really want our children to experience the world as we have – and to benefit from a truly exceptional transport system – then we need to start building it today.

Find out more at trapezegroup.com.au



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